

The 1970's

Guest Writer: [Jim Rosalanka](#)

Introduction

With the close of the 1960s, the American space program had made great strides with both its civilian and military components. The National Aeronautics and Space Administration (NASA) had reached its goal, established in 1961 by President John F. Kennedy, of "landing a man on the moon and returning him safely to earth." The landing of Apollo 11 in July 1969 has gone down as one of the landmark events of the 20th Century.

The U.S. military in the 1960s had developed the working technology with accompanying satellites, and required procedures to conduct its assigned space missions of reconnaissance, communication, and nuclear detection. It also conducted research and development programs (R&D) in the areas of navigation and early-warning. The USAF also established all the working infrastructure for launching spacecraft into either equatorial or polar orbit, and commanding and controlling these satellites once they were in orbit.

NASA continued into the 1970s with the launches of Apollo 13 through 17. The Apollo Applications program, later known as Skylab, established America's first space station and demonstrated the potential for man's continuous presence in space. The initial thawing of the Cold War gave the U.S. and the U.S.S.R. the opportunity for the first cooperative manned venture into space with the Apollo Soyuz Test Project (ASTP). But not all of NASA efforts were focused on manned spaceflight. This was also the great era of interplanetary space exploration to the outer planets with the flights of Pioneer 11 and 12, along with Voyager 1 and 2, and the landing of a spacecraft on Mars with Viking 1 and 2 in July 1976.

U.S. military spacecraft continued to be either developed or enhanced during the 1970s. Most military missions assigned to the USAF, Navy, or the Army were on their way to initial operations or at least were through final development. Two important points became quite clear during this time period. First, Los Angeles Air Force Base (part of Air Force Systems Command) became for all practical purposes a defacto military operational command. It controlled the Air Force Satellite Control Facility which handled many military satellites through its operations of Remote Tracking Stations, or RTSSs, throughout the whole world. It continued this important function for almost 25 years, starting in 1959, until the formation of Air Force Space Command in 1982. Second, the Navy pioneered the military space missions of tactical communications and space based navigation through its operations of the Fleet Satellite Communications Systems, known as FltSatCom, and Transit satellite system.

For the Soviet Union, the 1970s were a period of disappointment, but also a time of new beginnings. Russia had lost the manned race to the moon, both circumlunar and lunar landing. Its national pride was hurt, and to the world, it declared that it never was in a space race at all. Twenty years would pass before the truth finally came out. In the 1970s, they continued their unmanned lunar program with the Luna series, which included the first remote control rover on another planet called Lunokhod. Their overall space program was redirected towards the building and operating of a space station, and the enhancement of their manned Soyuz spacecraft. The Russians launched and manned the first earth orbiting space station in 1971, Salyut 1, but tragically, the crew perished during reentry after living and performing in space for almost 24 days. By the end of the decade, five more stations would be launched, three military and two civilian, with the end result that on-going operations were established by the Salyut series. In their planetary program, the Soviet Union was the first nation to soft-land on the planet Venus with the Venera series.

American Space Policy

When the foundation of the infant American space program was first considered in the mid 1950s, President Eisenhower initially wanted control of all programs in the hands of the military. However, the chairman of the President's Science Advisory Committee, James R. Killian, and then Vice President Richard Nixon, strongly recommended the establishment of a separate, and open civilian space agency. With the legislative help of Senator Majority Leader Lyndon Johnson, the National Aeronautics and Space Act of 1958 was passed, and NASA officially opened its doors for business on 1 October 1958. Hence, all American space activities were divided into civilian and military programs. Since early American space policy was driven by military requirements, by the end of the Eisenhower Administration, these space activities were further split into civilian, military, and reconnaissance missions. Early in the Kennedy Presidency, his administration codified the Eisenhower organizations with the civilian program controlled by NASA, the majority of the military missions managed by the USAF, and the reconnaissance program in the hands of the newly established National Reconnaissance Office (NRO). Air Force Undersecretary Joseph Charyk was named as the first Director of the NRO. When President Nixon took office in 1969, he kept intact the same national space setup, and all subsequent Presidents in the 1970s (Ford and Carter), also maintained this organizational status-quo.

Two major space policy decisions came during the Nixon Presidency (1969-1974) . These were the go-ahead to begin development of the Space Transportation System (STS), or the Space Shuttle as it was commonly referred to, and the initiation for the flight of the first U.S./U.S.S.R cooperative manned space flight, which became known as the Apollo Soyuz Test Project (ASTP). The eminent NASA space historian, Eugene M. Emme, once observed that "No President was ever to be in office when major space missions happened as a result of his initiative or decision." President Eisenhower began the American space program, including the manned Project Mercury, but it was President Kennedy who was to bask in its glory of astronauts Shepard and Glenn. Presidents Kennedy and Johnson initiated and enthusiastically supported the race to the moon with the Apollo Project, but it was President Nixon who was to meet the Apollo 11 astronauts on the U.S.S. Kearsarge in July 1969. It was President Nixon who came closest to seeing the fruits of his space decision-making with the ASTP. The formulation of the Apollo-Soyuz Test Project began as one of President Nixon's global diplomacy initiatives starting in 1972 when he and Soviet Premier Alexi Kosygin signed a mutual agreement. ASTP flew in 1975 which Nixon would have seen during his second term in office, but for the blunder of Watergate.

It would be President Ford (1974-1977) who would see the first historic space handshake between Tom Stafford and Alexi Leonov and the other astronauts of Apollo 18 and cosmonaut of Soyuz 19 of Apollo-Soyuz. No major space decisions occurred during President Ford's period in office. He supported the continued funding of the development of STS, and in fact, was present when the first Shuttle, Enterprise, made its public debut. He also dedicated in 1976 the most visited museum in the Washington, D.C., the Smithsonian's National Air and Space Museum.

Although President Carter (1977-1981) initiated no major space starts, he did make a launch vehicle decision that would drastically affect the military in the mid-1980s. His Secretary of the Air Force, Dr. Hans Mark, ordered that all military spacecraft were to be launched from the Space Shuttle once it became operational. He curtailed and discouraged the manufacture of expendable launch vehicles, such as the Titan, Atlas, and Delta family of rockets. That poor decision would haunt the military when the Challenger exploded in 1986, along with several Titan launch vehicles failures. This caused a major launch vehicle stand-down for almost two years, and no major military satellites were orbited during this time period. Also because of this, the French launch vehicle Ariane made significant inroads into the commercial launch vehicle business.

American Civilian Space Program (NASA)

INTRODUCTION

During the first half of the 1970s, with public support waning, and cutbacks in funding and personnel, the American manned space program achieved great results. From Apollo 13 (April 1970) through Apollo 17 (December 1973), eight more astronauts walked on the moon. Skylab began the U.S. venture into a permanent presence in space with three long-stay visits in 1973, which laid the foundation for the future International Space Station (ISS). Finally, international manned space cooperation started with ASTP, which would eventually lead to the mutually successful visits of the American Space Shuttle to the Russian space station Mir in the 1990s.

MANNED

The 1970s quite literally started off with a bang for NASA with the now famous words "Houston, we've had a problem" from the Apollo 13 commander, James Lovell, the first man to go twice to the moon. The launch of the planned third manned lunar landing began quite uneventfully on April 11, 1970. It was a sign of America's boredom with moon flights that live transmissions from the Command Service Module (CSM) "Aquarius" were not carried live by any major TV networks. Less than one day from lunar orbit, an oxygen tank exploded blowing the side of the CSM, and causing loss of most electrical power and oxygen. The only thing that saved the astronauts was the oxygen and power reserves in the Lunar Module (LM) "Odyssey", now called a lifeboat. The lunar landing was canceled, the astronauts retreated to this lifeboat, rounded the moon using the engines of the LM, and returned safely to earth on April 17, 1970. It would be almost a year before another lunar flight was attempted.

Apollo 14 was launched on January 31, 1971, commanded by America's first man into space, Alan Shepard, who had not flown since 1961 due to a inner ear problem. Because of his medical condition, Shepard was assigned as the chief of the astronauts corps under Deke Slayton. However, by 1969, he had returned to flight status, and using his powerful position, he was selected to command the Apollo 14 mission. This was much to the disappointment of many other experienced astronauts who had flown on previous Gemini and Apollo flights. His crew consisted of Stuart Roosa and Edgar Mitchell, both rookies. The assigned landing site was the Fra Mauro area, originally assigned to the Apollo 13 mission. Apollo 14 was the last "H" Apollo flights, which called for a limited stay on the moon, and no excursions beyond visual range of the LM. Liftoff was uneventful, but after insertion into lunar orbit, the CSM had to make six attempts to dock with the LM. Once in lunar orbit, and after separation between the CSM and the LM occurred preparing for the lunar landing, a computer fault developed activating the abort system. After fixing that problem, the landing radar failed, but Stuart Roosa overcame that difficulty. Apollo 14 landed just 90 feet short of its intended target. All exploration was successful, and one of the more memorable events of the mission was a game of lunar golf by Shepard, hitting the world's longest drive in history. Apollo 14 returned to earth on February 9, 1971.

The last three missions of the Apollo lunar program (Apollo 15, 16, and 17) were called "J" missions. Upgraded spacecraft systems, improved life-support equipment and space suits, and the introduction of the Lunar Roving Vehicle (LRV), greatly enhanced the scientific return of all these flights. All of these improvements would permit lunar excursions of 20 miles versus 2-5 miles with the previous Apollo "H" missions. It was with Apollo 17 that the first Scientist-Astronaut, Harrison Schmitt, a trained geologist, finally went to the moon. Apollo 17 was also the only night launch of a Saturn V. Manned lunar exploration ended with the landing of Apollo 17 on December 19, 1972. The cost to send twelve men to the moon was approximately \$24 billion dollars. Some say that it was not worth the cost, but most Americans look back at this period of time with great and understandable pride in the great accomplishments of American know-how, ingenuity, and technology. It appears that it will be a long time before such a feat is duplicated.

America's first, and so far its only, space station was the Skylab missions of 1973. The prime idea behind Skylab was to utilize as much as possible hardware and technology from the Apollo program. Skylab had its early beginnings from an original proposal from Douglas Aircraft Corporation in 1962, calling for modifying a Saturn IB second stage into a orbital station. Once in orbit, the second stage would be drained, and made habitable. This was known as the wet concept. Another concept called for using a Apollo CSM / LM combination as a long-term orbital space station. In 1965, the Apollo Applications Program (AAP) was setup within NASA and in that same year, the go-ahead was given for the Orbital Workshop (OWS) as part of the AAP. In 1970 this OWS formally became Skylab, but with a new twist. Instead of using a spent Saturn IB second stage (wet concept), the space station would be launched by a Saturn V, and be launched dry. But all this seemed academic when the Skylab was launched on May 14, 1973, and problems occurred immediately. Apparently, 63 seconds after launch, the micrometeorite shield came loose, taking with it one of two solar panels. To make matters worse, the remnants of the micrometeorite shield had jammed the other solar panel. Skylab was a useless piece of space junk, orbiting without power or thermal protection. But the ingenuity of flight controllers on the ground, and the repair mission of the first Skylab crew saved the station. This provided for three successful long-duration space stays of 28, 59, and 84 days in space. The 84 day Skylab record was not broken until 1977 with the flight of Soyuz 26 to the Salyut 6 space station. The scientist-astronauts (chosen in 1977) proved themselves a extremely valuable and worthy partner in space exploration, because Skylab 3 Commander, Alan Bean, claimed "the flight was 50 per cent more productive having (them) aboard " in earth resources and space sciences research. A derelict Skylab made a final curtain call in 1979 when it reentered the earth's atmosphere over Australia.

The call for international cooperation in space goes back to the earliest days of the space race. When the race was neck and neck, cooperative overtures were diplomatically rebuffed, but limited contact was maintained during the time period of 1962 through 1969. This was the political environment until Apollo 8 orbited the moon in 1968 and Apollo 11 landed on the moon in 1969. Again, President Nixon made overtures about a joint spaceflight in 1970 and the Soviet responded positively. A mutual agreement was signed in 1972. The original idea called for an Apollo spacecraft to dock with a Salyut space station, but this was changed to a linkup between a Soyuz and Apollo spacecrafts. NASA needed this flight desperately since no manned missions were planned for until 1978. The Skylab missions were scheduled for 1973 and the first Space Shuttle launches were not to occur until 1978-79 at the earliest (the first launch did not occur until 1981). Once the agreement was made, it took another three years (1972-1975) for the mutual docking device to be designed and manufactured (a Soviet design was accepted), and mutual operations to be agreed upon. It became know as the Apollo-Soyuz Test Project (ASTP). The American crew selected included a seasoned veteran, Tom Stafford, and two rookies, Vance Brand and Deke Slayton, although Slayton could hardly be called a rookie since he had been intimately connected with the American space program for 16 years when he finally flew on ASTP. This mission offered Deke, one of the original Mercury astronauts, the last opportunity to finally flew on a spacecraft. The Russians chose two veterans, Alexi Leonov, the world's first space walker, and Valery Kubasov. Soyuz 19 was launched first on July 15, 1975 and the Apollo 18 lifted off 7 _ hours later. The two spacecraft linked up two days later on July 17. They orbited linked together for three days before Soyuz 19 returned to earth. Apollo 18 stayed in orbit four more days. This was to be America's last manned mission for over six years. For the rest of the 1970s decade, NASA's manned flight focus concentrated on designing, building, and testing the Space Shuttle system.

SHUTTLE DEVELOPMENT

NASA began thinking about what would happen to the space program after the moon landings even before the first Apollo flight. Dreams about space stations and exploring the planets go back to the days of Hermann Oberth in the 1920s, and articles in Collier magazine by Wehner von Braun in the 1950s. When President Richard M. Nixon took office in 1969, he established a President's Space Task Group chaired by Vice President Spiro Agnew chartered with the task to determine NASA's future. This group came up with three options depending on how much money the government was willing to spend on the space program. Each of the proposed options consisted of two or more of the following pieces: a manned Mars expedition, a lunar space station, an earth-orbiting space station, and a reusable space shuttle. President Nixon eventually rejected all of the options. After intense lobbying by NASA Administrators Paine and Fletcher, along with Deputy Director of the Office of Management and Budget (OMB) Casper Weinberger, and realizing the potential problems from out-of-work Aerospace engineers in the 1972 election, Nixon approved the development of the Space Transportation System (STS). Once the program was initiated, design studies began. The original concept called for two components, all manned, recoverable and reusable - a booster section about the size of a Boeing 747, and an orbiter section about the size of a Boeing 707. Due to budget constraints imposed by OMB, and the need to meet defense launch requirements, the STS evolved into the present system: a manned orbiter, with two recoverable solid boosters, and an external fuel tank. The first orbiter, named Enterprise after the Star Trek TV series spaceship, rolled out of its production plant in September 1976. It began free flight tests from the top of a Boeing 747 mother ship at Edwards Air Force Base in the summer of 1977. First orbital tests were planned for the early 1980s.

INTERPLANETARY

Not all of NASA's efforts were focused entirely on manned spaceflight, although to most of its dedicated critics, it seemed that way. In the 1960s, America began exploring its planetary sisters, concentrating on Venus and Mars. However in the 1970s, NASA took more concentrated and sophisticated looks at Venus and Mars, and began initial exploration of the larger outer planets and Mercury.

NASA had planned later in the decade to land a probe on Mars, but it needed a detailed survey of the planet to determine a proper site. Previous Mars probes (Mariners 4, 6 and 7) had imaged less than 10% of the planet. The Mariner 7 series of two orbiter spacecraft (eventually Mariners 8 and 9) were managed by the Jet Propulsion Laboratory (JPL). After Mariner 8 experienced a launch failure, Mariner 9 was reprogrammed to survey the whole planet. Lift-off was on May 1971, and it successfully entered Mars orbit in November of the same year, becoming the first interplanetary probe to orbit another planet. Expectations were that imaging would begin immediately, but unusual dust storms covering the whole planet, the worst in a century, prevented this for two months. Since the planet could not be viewed for awhile, its moons, Deimos and Phobos, were photographed. By February 1972, the dust had settled, and the prime mission began. Volcanoes and valleys larger than anything on earth were discovered. The Valles Marineris canyon was found to be four to five times deeper than our own Grand Canyon, and could fit in the entire United States. The volcano Olympus Mons, which could be seen from Earth, was higher than any mountain here on our planet, with its base big enough to stretch from Los Angeles to San Francisco. Mariner 9 had collected 7300 photographs of Mars covering the whole planet during a 349 day mission.

The U.S. now turned to Jupiter and Saturn. One of the prime barriers to exploring these large outer planets was the asteroid belt between the orbits of Mars and Jupiter. Pioneers 10 and 11, launched in 1972 and 1973 respectively, were appropriately named and proved that spacecraft could safely travel this belt. Pioneer 10 would lead the way to Jupiter, while Pioneer 11, following in its predecessors footsteps, would also flyby Jupiter. In addition to passing by Jupiter and using a new technique of gravity assist, Pioneer 11 would then continue on to the first look at the planet Saturn. This gravity assist lets a spacecraft increase its energy and be deflected toward a different trajectory when passing by another planet due to the planet's gravity combined with its motion around the sun. Both missions were successful beyond expectations. Pioneer 10 returned the first close-up pictures, approximately 300 medium resolution images, of Jupiter and its moons before being whipped into a trajectory taking it past the Planet Pluto by the late 1980s. Thus, it became the first interplanetary spacecraft to leave our Solar System. Pioneer 11 encountered Saturn in 1979 after a voyage of six years, and passed within 20,000 miles of Saturn's outer ring. Its major discoveries included an additional outer ring of Saturn, and a new moon. Indeed, the Pioneers had paved the way for the future Voyager spacecraft.

The Planet Mercury has been visited by only one unmanned probe so far, Mariner 10 from 1974 through 1975. Though Pioneer 11 was launched before it, Mariner 10 was the first interplanetary spacecraft to use the gravity assist technique when it explored the Planet Venus one time, and then revisited Mercury three times. Most Mariner missions consisted of dual spacecraft, but Mariner 10 was a solo shot. Also, to hold down additional costs, the program used an Atlas booster with the Venus gravity assist, instead of the more expensive Titan III launch vehicle and a direct Mercury trajectory. Mariner 10 was launched on November 3, 1973, and when it passed Venus, it was slowed down, heading toward the Sun, and its intended target, Mercury. As it passed by Venus, the spacecraft took the ultra-violet images of that planet, showing for the first time, the fast wind speeds circulating around Venus. These extraordinary winds were later confirmed by other American and Soviet probes. Five months later (March 1974), Mariner 10 went by Mercury for the first of three visits, each about six months apart. Mercury turned out to be a heavily cratered place similar to our own Moon, and after three fly-bys, the spacecraft was able to photograph about 35% of Mercury's surface. Mariner 10 still visits Mercury every 176 days even though its payloads are long dead, and there are no immediate plans to revisit the planet in the immediate future.

During the 1960s, America had soft-landed an unmanned spacecraft (Surveyor) on the moon, but had made no such attempts on any of its sister planets. It had accomplished flybys to Venus, Mars and Mercury (in that order), but the 1970s would change all that with the Viking project and Mars was the target. Viking has started out as part of the more ambitious Voyager program which was canceled in 1967 for cost reasons (not to be confused with the Grand Tour Voyager spacecraft of the 1970s). The Vikings were resurrected in 1968 for launch in 1975. The space probes each consisted of an orbiter and lander, with a prime mission to seek out life on Mars. Viking 1 was launched in August 1975, and originally scheduled to land on Mars on July 4, 1976 (the 200th anniversary of the birth of the United States). However, once in Martian orbit, photography from the orbiter showed the original landing site to be too rocky. Other sites were examined, and the Viking 1 lander successfully arrived on the surface of the Red Planet on July 20, 1976. America's intense fascination with our planetary neighbor truly began. Viking 2 arrived at Mars one month later, and its lander duplicated Viking 1's feat by setting foot on the surface on September 3, 1976, some 7500 miles from its sister spacecraft. Joint operations began. Preliminary photographic scans of the Martian surface from both landers showed it to be an intensely rock covered with a rusty brown color. The pictures also showed no evidence of planet life, similar to our own Sahara desert. The Viking landers then began the second part of their job, examining Mars for microscopic life with its attached biology laboratory. The laboratory contained three experiments to probe for any life forms, but results were inclusive. Both sets of orbiters and landers continued their wide-ranging meteorological, geological, chemical and seismic studies for several years after landing. The last vehicle to be shut down was the Viking 1 lander in November 1982.

The most spectacular interplanetary missions to date have been unquestionably the flights of Voyagers 1 and 2. Launched in 1977, they did not complete their heavenly odysseys until 1989 when Voyager 2 flew-by the Planet Neptune finishing a journey that had its genesis in the 1960s. Scientists had earlier noted that the Outer Planets (Jupiter, Saturn, Uranus, Neptune and Pluto) had an unusual planetary alignment that occurred only once every 172 years, allowing one or two spacecraft to visit all of them at a minimum cost and time. One of these opportunities would occur in the 1976-1980 timeframe. From the "Mariner-Jupiter-Saturn 1977" studies of the late 60s, the "Grand Tour" was born. The original plan was to launch one spacecraft in 1977 with flybys of Jupiter (1979), Saturn (1980) and Pluto (1986), with another launch in 1979 going to Jupiter (1981), Uranus (1985) and Neptune (1988). Unfortunately, due to public apathy, escalating program costs (nearly \$1 billion), and increasing Space Shuttle developmental costs, the Grand Tour was canceled in 1972. The Voyagers were resurrected later in the year with the following restrictions - they were to be based on the successful Mariner-Viking designs, were to cost only half as much as the original Grand Tour project, and were to focus only on a more intense investigation of Jupiter and Saturn and its moons. However, JPL engineers and scientists planned for the possibilities of further explorations if funds held out, and they got their wish. What the World got was a voyage through our whole outer planetary system except for Pluto. Voyager 2 was launched before Voyager 1 in August 1977, and was directed toward a more thorough examination of Jupiter and Saturn. Voyager 2 began its journey in September 1977 and ended its mission in 1989 when it explored Uranus and Neptune. What both spacecraft discovered was breathtaking. Voyager 1 discovered that Jupiter had rings like Saturn and Uranus, while finding two new additional Jovian moons, raising the total to 16. Upon passing Jupiter's moon Io, Voyager revealed active volcanoes, making Io one of the most geologically active moons in the solar system. Upon reaching Saturn, Voyager 1 discovered three new moons of that planet, further investigated the intricacies of its rings, and thoroughly examined the Saturnian moon Titan. After that, Voyager 1 had finished its mission and became an interplanetary sojourner. Voyager 2 followed Voyager 1 in exploring Jupiter and Saturn, discovering additional rings around Jupiter. Voyager 2 then proceeded to Uranus and Neptune. At Uranus, Voyager discovered ten new moons, and two new rings. Finally 12 years after its launch, Voyager 2 flew by the planet Neptune. It soon joined the other interplanetary travelers, Pioneers 10 and 11, and Voyager 1 in their paths out of our solar system.

The last mission for the Golden Age of Interplanetary Exploration was Pioneer-Venus 1 and 2, also sometimes called Pioneers 12 and 13. These spacecraft were our nation's only dedicated flights to the Planet Venus in the 1970s, even though Mariner 9 had used a gravity assist from Venus on its way to explore Mercury. Pioneer-Venus consisted of two spacecraft, each one launched by an Atlas-Centaur booster. Pioneer-Venus 1 was an orbiter vehicle, also called Pioneer-Venus Orbiter or PVO, whose prime mission was to study the Venusian atmosphere long term and map the surface using a radar instrument. Pioneer-Venus 2 was a multi-atmospheric probe, consisting of a bus with four probes which would penetrate the Venus atmosphere and sample the high-wind, high-pressure environment before burning up during their descent. Pioneer-Venus 1 (PVO) was launched on May 20, 1978 and entered Venusian orbit on December 4, 1978. The radar mapper on the PVO allowed a construction of a topographical map of Venus with a 75 km resolution. It showed the planet to have no polar flattening or equatorial bulge like Earth, due to Venus's slow rotation rate of 243 Earth-days. The PVO also examined the Venusian atmosphere down to 31 km (the limit of its capability), and found that most of the cloud cover probably consisted of sulfuric acid. Pioneer-Venus 2 (the atmospheric probe) was launched on August 8, 1978, and all probes entered Venusian atmosphere on December 9, 1978. Two of the probes entered the day side of the planet, while the other two entered the night side. The Pioneer-Venus 2 probes discovered that the upper atmosphere rotated once every four days around the planet, and the cloud covers definitely consisted of sulfuric acid droplets. Thus ended the flight of America's last interplanetary mission launched in the 1970s.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

Besides manned spaceflight and interplanetary exploration, NASA also had the charter to advance the state-of-the-art for spacecraft design and applications, space science studies, and earth application satellites. In the early 1960s, NASA began weather reporting by developing the medium orbit Television and Infrared Observation Satellite (TIROS), and the polar orbit more advanced Nimbus spacecraft. It continued with earth studies using the Explorer series of satellites. It started the more complex Orbiting Observatories series (Solar, Astronomical, and Geophysical) which were to study the heavens from medium earth orbit. Finally, to advance satellite technology, NASA orbited the Syncom group of satellites which were the first communication spacecraft put into geosynchronous orbit, and the Applications Technology Satellites (ATS) to push the state-of-the-art for communications satellites. In the 1970s, NASA built on this foundation established in the 1960s. It continued developing weather satellites with the Improved TIROS Operational Satellites (ITOS), and eventually turned over day-to-day operations to the National Oceanographic and Atmospheric Administration (NOAA). In the mid 70s, NASA designed the Synchronous Meteorological Satellites (SMS) that evolved in the Geostationary Environmental Operational Satellites (GEOS), which are also handled by NOAA. Our present day TV weather reports are provided by the GEOS system. The Orbiting Observatories satellites were continued, along with a new series, the High Energy Astronomical Observatories (HEAO). Finally, a new applications satellite was tested to perform earth remote sensing, and was initially called the Earth Resources Technology Satellite (ERTS). It was later renamed LANDSAT.

American Military Space Program: Initial Military Operations

INTRODUCTION

The practical beginnings of the total American space program had its roots in military space requirements. The first American military service to investigate the potential of satellites was the Navy in 1946. When the Air Force learned of the Navy activities, it asserted its rights to this new area as a logical extension of its air mission. During the late 1940s and 50s, the USAF directed the RAND Corporation to study the feasibility of satellite systems and associated launch vehicles. These studies identified the military missions of weather, communications and reconnaissance. Between 1953 and 1956, the Air Force initiated a "Satellite Component Study" giving it an official designation of Weapons System 117L or WS-117L, issued a system requirement and established a general operational requirement, and finally approved a development plan in 1956. The Air Force was on its way into space. WS-117L was envisioned to be a family of subsystems designed for different missions, including photo reconnaissance and missile warning. By the end of 1959, 117L had become three distinct programs - the Discoverer Program, SAMOS or Satellite and Missile Observation System, and finally MIDAS or Missile Detection Alarm System. The Discoverer Program and SAMOS were to be photo reconnaissance satellites, and MIDAS was for missile warning. In 1958, the Weapons System designation was dropped due to President Eisenhower's stated space policy of "freedom of the skies" and "the peaceful uses of space." Using WS nomenclature might be misinterpreted by the Soviets as a non-peaceful use of space. However, in the end, these three pioneering systems and associated launch/booster systems gave the American military space program its beginnings.

PHOTO RECONNAISSANCE

The Discoverer Program officially had 38 launches, but in reality had many more. This program was a cover for the covert, intelligence-gathering reconnaissance satellite called CORONA, which was declassified in 1995. Its aim was to develop a film-return photo reconnaissance satellite using the Thor-Agena launch vehicle combination. There were a total of 134 launches between 1959 and 1972. Of these 134 launches, 102 were considered successful. In the 1970s, there were 8 CORONA missions, also known as KH-4Bs. These CORONA KH-4Bs each had two re-entry vehicles or RVs carrying photographic film, had an average mission life of 19 days, and carried out stereo photography of denied areas. In 1997, the Smithsonian's National Air and Space Museum opened up a display called the "Space Race" which showed a full scale CORONA KH-4B to the general public for the first time. However, the distinction of having the first ever public showing of an NRO system goes to the Schriever Exhibit at the Air Force Space and Missile Museum, Cape Canaveral, Florida in 1996.

WEATHER (METEOROLOGY)

At the beginning of the American space program, NASA was given the overall responsibility of developing and operating a weather satellite system that could meet both civilian and military needs. NASA launched these first weather satellites, TIROS 1 and 2 in 1960. However, the NRO believed the TIROS system could not meet the strategic meteorological needs of the CORONA system. The first Director of the NRO (DNRO), Joseph Charyk, pushed for a separate weather satellite, and set up the Defense Meteorological Satellite Program or DMSP. The first DMSP satellite was launched in 1962, and by 1964, four weather satellites were operational, still awaiting the full capability of the NASA system. In 1962, DMSP provided the National Command Authority (NCA) with critical cloud cover information on the Soviet Union and the Caribbean during the Cuban Missile Crisis. In 1965, the NRO gave total management responsibility of the DMSP program over to the Air Force, making the system an official military asset. The USAF has overseen the development of DSMP ever since. These satellites provided critical support to our troops during the Vietnam War, especially during air strike planning phases, saving lives and money. Most initial military satellites systems were designed for strategic use, but the DMSP system was the first spacecraft that both the Air Force and the Navy made tactical use of its weather data, primarily in strike aircraft mission planning. The Navy even put receivers on carriers to receive cloud cover information for its attacks in North and South Vietnam. These receivers have become standard equipment for the Navy since that time. The DMSP system was officially declassified in 1973. These satellites are polar orbiting, sun-synchronous spacecraft, with at least two in orbit at all times. The DMSP system has gone through nine different design changes or upgrades through its operational lifetime, Blocks 1, 2, 3, 4, 5a, 5b, 5c, 5d-1 and 5d-2 - four during the 1970s. In fact, the last Block 4 satellite, Flight 23, was donated to the Museum of Science and Industry in Chicago, and is on display there. There were a total of 15 DSMP launches from 1970 to 1979, with 14 being successful. The launch vehicle for DSMP in the 70s was the Thor-Burner II and Burner IIA. In the beginning, these military weather satellites were designed to provide day and night visual cloud coverage. Now, other instrumentation now include finer resolution cloud cover sensors, temperature/moisture sounders, aurora detectors, and an infrared sounder. By the 1970s, the Air Force had two readout stations for the DMSP system in the Continental United States in the state of Washington and Maine, which feed this information to the Global Weather Central facility at Offutt Air Force Base in Omaha, Nebraska.

NUCLEAR DETECTION

By all accounts, the Vela nuclear detonation detection satellite system has been one of America's most successful military space programs ever. The reason for building the Vela system was to monitor compliance with the 1963 Limited Nuclear Test Ban Treaty. The total number of satellites built was 12 - six of the Vela Hotel design, and six of the Advanced Vela design. The Vela Hotel series was to detect nuclear explosions in space, while the Advanced Vela series was to detect not only nuclear explosions in space but also in the atmosphere. All spacecraft were launched in pairs, either on a Atlas-Agena or Titan III-C boosters, and placed in 63,000 to 70,000 mile orbits, well above the Van Allen radiation belts. The first pair was launched in 1963, three days after the Test Ban Treaty was signed, while the last pair was launched in April 1970. The last satellite to be shut down was Vehicle 9 in 1984, which had been launched in 1969. It had lasted 15 years. Vela started out as a small budget research program in 1959. It ended 26 years later as a dramatically successful, cost-effective space system. In the 1970s, the nuclear detection mission was taken over by the Defense Support Program (DSP) system, and in the late 1980s, by the Navstar Global Positioning System (GPS) satellites. Some controversy still surrounds the Vela program when in the late 1970s, one of the satellites detected an atmospheric nuclear explosion allegedly in South Africa. Many scientific and policy experts at that time (during the Carter Administration) took pains to debunk the data as a false reading. However, in the mid-1990s, South Africa openly admitted they had conducted an atmospheric nuclear test at that time. The satellite was RIGHT!

COMMUNICATIONS

Military communications has two very distinct requirements - one is strategic communications serving users who have medium to high rate data needs using large stationary ground terminals usually between fixed bases, and the other is tactical communications serving users who have low to medium data rates using small, mobile terminals. Military satellite communications during the 1970s included further development of strategic communications and initial development of tactical communications. The military took its fledgling steps toward solving its strategic needs with the Initial Defense Communications Satellite Program or IDCSP in the 1960s. When IDCSP reached initial operational capability (IOC), the system was renamed the Defense Satellite Communications System I (DSCS I). Later in its use, DSCS I proved it also had tactical capability. In mid 1969, DoD gave the go-ahead to develop the next stage of strategic military communications, a satellite that would use the geosynchronous orbit (at 22,300 miles) called DSCS II. DSCS II would be larger, offer increased capability than DSCS I, and have a longer lifetime than its predecessor. The satellites were to be launched in pairs aboard a Titan III-C booster. Though once in orbit, these satellites performed well, their launch track record was spotty at best. The first pair was launched in 1971, but quickly experienced operational problems once in orbit. It took six months to overcome these problems and make the satellites usable. DSCS II underwent a major redesign based on the problems of the first launch, and a second pair were launched in 1973. A third pair of DSCS II satellites failed to reach orbit in 1975. The next set reached orbit in 1977, while the fifth pair again was a launch failure. A sixth set was launched in 1978, and the Air Force could now finally claim a full operational DSCS II constellation after seven years of trying with four operational, geosynchronous satellites and two on orbit spares. In 1973, the Air Force began designing the next generation communications satellite, DSCS III. It called for increased communications capacity, particularly for mobile terminal users, and for improved survivability. Though planning for DSCS III began in 1973, the first launch did not occur until 1982.

Developmental testing of tactical communications satellites began in the late 1960s with the launch of the Lincoln Experiment Satellites (LES) 5 and 6, and the Tactical Communications Satellite or TACSAT I. All three satellites operated at ultra and super high frequencies, and tested the feasibility of supporting small, mobile antenna users. In July 1970, initial operational capability was declared for tactical requirements using LES 6 and TACSAT I. However, it was the Navy who took the initiative to fully develop a complete operational system solely serving the tactical user, called Fleet Satellite Communications System or FLTSATCOM. This system was an outgrowth of the LES satellites and TACSAT I. Development of FLTSATCOM began in 1971, with five satellites launched between 1978 and 1981, with one failure due to damage during boost phase. Program management was totally under the control of the Navy, but the satellites were acquired by the Air Force through the Space and Missile Systems Organization at Los Angeles Air Force Base for the Navy.

There is one final communications customer, the nuclear capable forces. It was through these users that our nation's strategic nuclear forces are controlled. These users required low data rates like tactical users, but needed high availability, worldwide coverage, and maximum survivability. Their needs were met with the space element of the Air Force Satellite Communications System (AFSATCOM). These transponders were placed on FLTSATCOM satellites and Satellite Data System (SDS) spacecraft.

EARLY MISSILE WARNING

Surprisingly, the military space mission of early missile warning was not identified by any of the RAND studies of the late 1940s and early 1950s investigating the feasibility and usefulness of satellites. Therefore, it is amazing that by 1980 space based infrared systems were considered the fourth leg of our country's nuclear deterrent "Triad" of bombers, land based ballistic missiles and sea launched ballistic missiles helping to deter any nuclear attack against the United States. Infrared detection of missile launches for early warning was one of the three primary missions of the earliest USAF development for a reconnaissance satellites. The primary driver behind this early warning requirement, to prevent a nuclear Pearl Harbor, was Strategic Air Command (SAC) commander General Curtis LeMay, who needed time to launch his strategic bombers in case of an attack on the Continental United States. In 1956, when Lockheed won the contract to design, develop and build America's first military satellite, a young engineer named Joseph Knopow proposed, as part of the winning design, using an infrared (IR) radiometer to detect hot exhaust gases of bombers and rockets. The project's objective was to put an IR sensor and telescope in a rotating turret into the nose of an Agena upper stage launch vehicle. The system was to be launched by an Atlas-Agena rocket booster. The IR sensor was to be designed by Aerojet Corporation, and the overall satellite and system integration was to be accomplished by Lockheed. This system eventually became known as the Missile Detection Alarm System or MIDAS. MIDAS satellites were to be placed into 2000 miles polar orbits to detect missile launches from the Soviet Union. Unfortunately, MIDAS experienced problems from the beginning, the two worst being continuous budget cuts and requirements creep. The original mission of MIDAS in 1956 was strategic early warning, but by 1965, its missions included greater system reliability beyond several weeks operations, global coverage instead of just the Soviet Union, launch point determination, and real-time detection of nuclear detonations. MIDAS faced one major acquisition and three operational hurdles. The acquisition hurdle was how long should a program stay in the study and developmental stages before fielding it as an operational system, particularly when the system is a much needed but technologically challenging product. The USAF desperately needed a warning system as advocated by General LeMay, but an IR sensor in space had never been tried, let alone used. The three major operational hurdles included detecting low radiance missiles such as solid rocket ICBMs besides large liquid ICBMs, discriminating rocket IR exhaust emissions from background emissions from clouds and reflections from the sun, and finally long-term system reliability. 1960 was a time when just getting a satellite into orbit was a minor miracle, let alone getting the systems to work for a long period of time. The program's earliest launches between 1960 to 1962 either didn't make it into orbit (MIDAS 1 and 6), or only lasted for a very short time without providing any useful or limited data (MIDAS 2, 3, 4 and 5). Again between 1960 and 1962, the Office of Secretary of Defense (OSD) and Secretary of the Air Force (SAF) directed three major reviews of the program to decide if it was going in the right direction or if this system was needed at all. But after each review, the operational Air Force forcefully backed the requirement for a space based early warning system. By 1962 MIDAS had become Air Force Program (AFP) 461. In 1963, the long years of work finally paid with two successful AFP 461 launches which demonstrated beyond a shadow of a doubt that early missile warning was indeed possible and obtainable. Finally in 1966, two out of three launches were highly successful and lasted over a year. The questionable reliability of the system had been resolved. This time, SAF would permit the USAF to start fielding an operational space based IR system. In 1966, based on the successes of that year, the program was redirected again by OSD and SAF because of three factors. The first factor was the appearance of a new threat, the Fractional Orbital Bombardment System or FOBS that the Soviet Union had begun testing on, which could launch a nuclear attack against the US from the South Pole. The second factor was the addition of the nuclear detection mission as part of the new IR system. The VELA nuclear detection system was coming to the end of its operational life, and a new space platform was needed to continue this mission. The final factor was an idea proposed by two Aerojet engineers. The original MIDAS system had a spinning sensor inside the nose of a spacecraft at a medium polar orbit (2000 to 6000 miles). The two engineers, John Jamieson and Robert Richards, proposed using a spinning satellite at a geosynchronous orbit. At geosynchronous orbit, it would take only three satellites to provide total global coverage instead of the originally proposed eight to twelve satellites in polar orbit, and with a spinning satellite, the electronics needed for the system were greatly simplified. Also, the new system would be launched by the USAF's newest heavy lift booster, the Titan III-C. The new program, AFP 949, was initiated in August 1966, and the first launch occurred in November 1970. This first DSP satellite was the first military satellite to utilize a geosynchronous orbit to accomplish its mission. This program eventually became known as the Defense Support Program or DSP. In 1971, the Overseas Ground Station (OGS), located in Woomera, Australia took over operational control of the satellite. In 1972, a Continental Ground Station (CGS), located at Buckley Air National Guard Base, near Denver, Colorado, joined the system. In 1972 and 1973, two additional satellites joined the constellation. During the 1970s, a total of eight DSP satellites were orbited each using 2000 short wave infrared (SWIR) detectors to accomplish their task. During this time period, DSP underwent three design changes including Phase I (Flights 1-4), Phase II (Flights 5-7), and Multi-Orbit Satellite/Product Improvement Modification (MOS/PIM) (Flight 8). Before DSP became operational, the US depended upon radar sites located across Canada and other sites to provide early warning to the National Command Authority. When DSP was first launched in 1970, it provided critical backup to these radar sites. By 1975, DSP was given co-equal status with the radar sites to provide early warning. By 1980, DSP had become so reliable, that the radar sites were abandoned. Space based infrared systems providing early missile warning had progressed and matured considerably from MIDAS to DSP. DSP had become the new space guardian overseeing and protecting our nation from any future strategic Pearl Harbors.

NAVIGATION (GLOBAL POSITIONING)

The military mission of navigation is as old as history itself, and space based navigation is nothing more than the latest method to answer the question, Where Am I? Again, like tactical communications, the Navy pioneered the use of satellites to determine locations on earth, with its Transit system, which became our country's first operational military space system. The Navy's prime requirement was to provide position data to its ships and submarines. The first Transit launch was in 1960, was fully operational by 1964, and was widely used by both the Navy and commercial shipping. It gave location in two dimensions (longitude and latitude) with an accuracy of 200 feet. The only drawback to this system was that it did not give altitude or velocity which made it not very useful for high speed aircraft. In 1964, both the Navy and the Air Force began studies investigating how to upgrade and improve the system to give three dimensional coordinates with velocity and time. The Navy program was called Timation, for Time Navigation, and envisioned a constellation of 21 to 27 satellites in a medium altitude orbit (8 hour orbit) with improved atomic clocks. In fact, the Navy launched two Timation satellites in the late 1960s to test the improved features of their system. The Air Force version was 612B with a proposed constellation of 20 satellites at a geosynchronous orbit. The ability of this system was ground tested at White Sands Proving Ground during the early 1970s, and showed position accuracy of 50 feet. However in 1973, DoD directed that a joint program office for space based navigation be formed with the Air Force as the lead military service. Colonel Bradford Parkinson (USAF) was selected as the first program manager with the given charter to develop a joint initial concept and gain DoD's approval to field the system. What evolved was a system that used the best of both, using the signal structure and frequencies of 612B and the medium altitude orbits and number of satellites similar to those of Timation. Originally the constellation was to have 21 satellites in three orbital planes, but this was later expanded to 24 in six planes of orbit. This would be the largest single constellation of spacecraft controlled by the military. GPS start was authorized in December 1973, and was acquired in three phases. The first phase, validation of the GPS concept, occurred in the 70s. This included building Block I navigation satellites along with a prototype control segment. The first four Block I satellites were launched in 1978, four years after initiation of the program. This permitted full scale testing from Yuma Proving Grounds in Arizona using aircraft, helicopters, tanks, jeeps, and with ships at sea. The Defense Department authorized full scale development in 1979. Navstar GPS would not realize its full potential for another 10 years and would include a war.

SPACE INTRASTRUCTURE AND ORGANIZATION

A complete space system consists of five different segments to be fully functional. They are:

1. a space segment (the satellite you want to orbit, or interplanetary probe you launch for exploration)
2. a ground segment (the place where you talk to satellites - this can be either a common user or mission unique system)
3. a communications segment (the means for talking between the space and ground segments)
4. a launch segment (the rocket to put your satellite into orbit, or beyond)
5. a user segment (the people who want the data gathered by your satellite - in the space business, this segment is considered the most important since they control the money)

By 1970, many of these segments were completely operational for military systems, with many undergoing upgrades to improve their performances. Many military space missions (the space segment) were established in the 1960s such as reconnaissance (Corona), navigation (Transit), weather (DMSP), nuclear detection (Vela), and communications (IDCSP). Other missions had begun concept or developmental testing such as early warning (MIDAS). Many more systems became operational or had began development in the 1970s such as early warning / nuclear detection (DSP), strategic communications (DSCS II), tactical communications (FltSatCom), and navigation (GPS). Two crucial segments, the ground and communications, underwent vast improvements in the 1970s to increase their capabilities. The military ground segment was called the Air Force Satellite Control Facility or AFSCF. It consisted of a centralized command and control center (the Satellite Test Center or STC) located at Sunnyvale AFS, California and seven Remote Tracking Stations or RTSs, located through the world. It was the communications segment that connected this dispersed group of RTSs with the STC, first by land lines, radio stations, and submarine cables in the 1960s, leading to communications among this group of facilities by satellites (DSCS II) by the end of the 1970s. By the beginnings of the 1970s, Cape Canaveral AB in Florida was the main launch site for military satellites going into geosynchronous or equatorial orbit, while Vandenberg AFB in California became the launch site for satellites going into polar orbit. Both sites in Florida and California could handle most types of launch vehicles including Thor, Atlas, Deltas, and Titans with numerous combinations of upper stages. The irony of this whole situation was that since the prime function of the Air Force was to fly and fight with aircraft or strategic nuclear war with bombers and ICBMs, the new mission of space was left to the research, development and acquisition community of the USAF. Therefore from 1959 with the first launch of Discoverer I from Vandenberg AFB to the activation of Air Force Space Command in 1982, Los Angeles Air Force Base, first known in the 1960s as Space Systems Division then Space and Missiles Systems Organization (SAMSO) in the 1970s, had become a defacto operational command for military space systems. As Dave Spires in his book BEYOND HORIZONS says, "...organizational developments enhanced the control of a research and development command over space systems that were becoming increasingly operational."

Russian Space Program

INTRODUCTION:

During the late 1950s and 1960s, the dominant space power was the Soviet Union. Except for manned circumlunar, manned lunar landing, and exploration of the outer planets, all of the major space firsts were accomplished by Russia. These firsts included the first satellite (Sputnik 1, 1957), the first probes to hit and take pictures of the moon (Luna 2 and 3, 1959), first interplanetary probe (Venera 1, 1961), first man in space (Vostok 1, 1961), first woman in space (Vostok 6, 1963), first multi-manned spacecraft (Voskhod 1, 1964), first walk in space (Voskhod 2, 1965), first softlanding on the moon (Luna 9, 1966), first probe to orbit the moon (Luna 10, 1966), first unmanned lunar soil sample return mission (Luna 16, 1970), first unmanned planetary rover (Luna 17/Lunokhod 1, 1970), first object on Mars (Mars 2, 1971), first Venus lander (Venera 7, 1970), and first Venus orbiter with lander and surface pictures (Venera 9, 1975). But this all came crashing down in January 1966 when the "Chief Designer", the soul of their space accomplishments, Sergei Korolev, died during an operation. Their space program never fully recovered, and they lost the race to put a man on the moon. The problem of the Soviet space program was two-fold. First, whereas in the United States, NASA was the one central organization who was responsible for leading the race to the moon, the Soviet Union had competing design bureaus which very rarely cooperated on such important ventures. Secondly, the Soviet Union did not have the financial resources to compete. The United States spent approximately \$24 billion to get a man on the moon. It has been speculated that Russia spent less than half that. When the race was lost, the Soviet Union denied that they had ever been in one. The truth came out during the era of perestroika. But where there are endings, there are new beginnings. The Soviet program was re-oriented to further unmanned exploration of the moon with their Luna series of planetary spacecraft, and the launching and maintaining of space stations in orbit. The 1970s would be a time of trial and error, but by the end of decade, two very successful space stations, Salyut 6 and 7, would be manned for long time periods. Russia would also continue its very successful exploration of Venus including the first soft landing on that planet.

MANNED:

When In July 1969, the Soviet Union lost the race to get a man on the moon first, they did not completely dismantle their lunar program. Their basic manned spacecraft had been successfully tested in earth orbit. The manned lunar system was called the L-3 complex, and consisted of two distinct spacecraft. The first was the LOK lunar orbiter (or L-1) and was similar to the American Apollo Command and Service Module complex. The second was the LK lunar lander (or L-2) and was similar to the American Lunar Module. The LOK lunar orbiter was based on the successful Russian Soyuz spacecraft design and had overcome early failures like the Soyuz 1 disaster which had killed the cosmonaut, Vladimir Komarov. The LK lunar lander had been tested in earth orbit under the Russian Cosmos series, similar to what the Americans did with the Apollo 9 flight. But the Russian could never get their large lunar booster, the N-1, to work. In size, the N-1 was comparable to the American Saturn V. However, in four launch attempts between 1969 and 1972, the N-1 failed to even get into earth orbit. The N-1 program was officially canceled in 1976. After the bitter national loss, the Communist Party redirected the space program toward space stations and the continued development of its Soyuz spacecraft.

Both the Soviet and the American space program had their roots in the same dream, that began with Jules Verne to Constantine Tsiolkovsky to Hermann Oberth. From these early visionaries, the plan was to go into earth orbit first, then a space station, and finally exploration of the Moon and then Mars. The race into space jumped one of steps by going to the Moon after going into earth orbit. In the 1960s, both American and Russian programs seriously looked at space stations. The American program began with the Apollo Applications Workshop that eventually led to the Skylab space station. In the Soviet Union, the need for a space station was first looked at by the Korolev Design Bureau in 1962, which would have been launched by the then fledgling N-1 booster. But since the Korolev Bureau was assigned the task of getting a Russian man to the Moon, the Chelomei Design Bureau was given the space station task which later became known as Almaz. The requirement for Almaz originally came from the military, in response to the American Manned Orbiting Laboratory or MOL program. Where the Korolev Bureau designed the R-7/A-2/Soyuz rocket launcher that is still used today, the Chelomei is best known for the UR-500K rocket booster commonly called the Proton rocket. It also is still used today, and is Russia's heavy lift booster. Chelomei designed an integral station unit that included the booster (Proton), the space station (Almaz), a return capsule called Merkur, and a logistics unit called TKS. By 1968 the basic design was complete but subsystem production was behind schedule. In 1970, all the work was transferred to the Korolev Bureau where subsystem design and production was completed. The push for final manufacture was to beat the American Skylab station into orbit. The Korolev Bureau took the basic Almaz shell and then added various subsystems from their Soyuz spacecraft to complete the total system. This combination of an Almaz shell with Soyuz parts was called by the Soviets their Long Duration Station or DOS, but has been commonly referred to as Salyut. Salyut 1 (DOS 1/Civilian) beat Skylab into orbit (1971 versus 1973) by almost two years, but trying to man the space station first proved to be trying and then unfortunately ended in tragedy. Soyuz 10 was the first crew to try and activate Salyut 1, but the spacecraft could never properly dock with the space station. Soyuz 11 was launched and docked with Salyut 1 and completed a successful 24 day mission. But it was with the undocking from Salyut 1 to return to earth that an air pressure valve, normally activated after reentry, accidentally opened in orbit depressurizing Soyuz 11 and killing the whole crew. This was due in part to the crew not wearing any pressure suits. Russia had its second set of space casualties with burial in the Kremlin Wall.

It would be two years before the Soviet Union attempted any new manned flights. By then, the Soyuz spacecraft had been redesigned to carry only two cosmonauts but with complete pressure suits to avoid any more Soyuz 11 incidents. Also, the space station had evolved into two distinct and separate programs, one civilian (Salyut/DOS) and the other military (Almaz), even though all subsequent launches would be called Salyut. A second Salyut/DOS/Civilian station was launched but never reached orbit. The next attempted launch occurred in 1973 but the Salyut 2 (Almaz 1), the first military station, would not stabilize in orbit, began to tumble, and soon reentered the earth's atmosphere. A third DOS-type station was launched in May 1973 but suffered attitude control system failures. Salyut 3 (Almaz 2) was launched in June 1974 and was the first successful Almaz military station. It was manned several times but few details have emerged about this flight. Salyut 4 (DOS-4) was the second DOS station to be manned and the first completely successful civilian space station. A total of three crews were orbited with Salyut 4 between 1974 and 1977. The next space station was Salyut 5 (Almaz 3) and was the last totally military space station to be launched. It conducted operations from 1976 through 1977 and manned by three crews. Salyut 6 (DOS-5) was the third civilian station to be manned. It also had two docking ports on the station, both front and aft, and was the first station to be resupplied by the new Progress unmanned logistics spacecraft. All previous Salyut space stations, both Almaz and DOS, had only one docking port, at the very front. But the redesign permitted resupply and therefore extended stays in space. Salyut 6 was to last into the early 1980s. With Salyut proving itself in orbit, in 1978 the Soviet space program initiated the Intercosmos program where cosmonauts from Eastern Block and other communist countries would be allowed to spend a short time in orbit. By the end of the 1970s, cosmonauts from Czechoslovakia, Poland, and East Germany had visited the space station.

The Soviet space design philosophy has always been evolutionary versus the American style of revolutionary. The American manned program went from a reliable Apollo system to the quite untried and revolutionary lifting body Shuttle system. The Soviet system can be seen in the design evolution of both the Soyuz and Salyut space stations. In the Salyut/DOS/Civilian series of space stations, Salyut 1 was built up from an Almaz shell and one docking port with numerous subsystems from the Soyuz spacecraft, including attitude control, propulsion, main control panel, and 2 sets of solar panel wings on the front and back of the station. The next DOS station, Salyut 4, had the basic systems of Salyut 1, but now three large solar panels were mounted on the central body of the space station. Salyut 6, the third DOS/civilian station, took the Salyut 4 design and now included a second docking port on the rear of the station, and redesigned the propulsion unit. The Soyuz design evolution went from the basic Soyuz design, to the Salyut 1/Soyuz design, Soyuz ferry, Soyuz T, and finally Soyuz TM which is the present manned system being utilized. The Soyuz system consists of a service, descent and orbital modules. In many ways, the Soyuz and Apollo manned systems were quite similar, except that the Soyuz had separate descent and orbital modules. The Soyuz orbital module was used as a laboratory and storage area, where the Apollo system combined both these functions into the command module. In the basic Soyuz design, which carried three cosmonauts, there was a docking mechanism but not tunnel for cosmonauts to move from spacecraft to spacecraft. In the Salyut 1/Soyuz design, a tunnel was now in place, but now only two cosmonauts were launched. In the Soyuz ferry, the solar panels were removed, and batteries were the main electrical power. Soyuz T put back the solar panels, and for the first time in over 10 years, three cosmonauts could now be launched in the system. With these two very reliable systems, the manned Soyuz spacecraft and the Salyut space station, the Soviet space program had found a new focus and would be again the pioneering nation in the area of extended stays in space. The second part of the visionaries space dreams - earth orbit, space stations, and planetary exploration - was now a reality, and the Soviet Union was the leader.

PLANETARY

The 1970s were a bountiful time for Soviet planetary exploration including 9 probes to the Moon, 6 spacecraft to Venus, and 6 missions to Mars. Many of these missions included many firsts.

After the demise of their manned lunar program, Russia continued their lunar exploration with unmanned devices, possibly as a way to show the world that unmanned probes were cheaper than manned flights. Their unmanned lunar program included both sample return missions and remotely controlled rovers. The Soviets accomplished three successful lunar sample return missions - Luna 16 (1970), Luna 20 (1972), and Luna 24 (1976). Many of the samples recovered were exchanged with both American and French scientists for analysis. They also accomplished two successful remote controlled lunar rover missions - Lunokhod 1 attached to Luna 17 in 1970 and Lunokhod 2 attached to Luna 21 in 1973 - something that the United States was not able to do for over 25 years until 1997 with the Mars Pathfinder mission. Each Russian rover mission lasted between 4 months and 1 year after landing on the Moon's surface returning thousands of pictures.

The premiere explorer of Venus is still the Soviet Union/Russia today. This is proved not by the number of probes sent to Venus, but by the quality and accomplishments of these missions. The first probes sent in the 1970s were planetary probes that hopefully might reach the Venusian surface. These included Venera 7 (1970) and Venera 8 (1972) which indeed both penetrated the Venus atmosphere farther than any previous spacecraft. Venera 8 is believed to actually have landed on the surface before succumbing to Venus's heat and pressure. Venera 9, launched in 1975, was Venus's first man-made orbiter which sent down a probe that successfully transmitted the first pictures of that planet's surface. Subsequent probes, Venera 10, 11 and 12, performed the same missions. The United States has not been able to duplicate this feat yet.

The Soviet Union's Mars program sent 6 spacecraft to that planet during the 1970s, Mars 2,3,4,5 and 6. Their accomplishments include the first object to land on Mars (Mars 2 and 3) but not much more than that. Russia had better success with Venus, and they concentrated on that.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

The Soviet space program did not just include satellites for their premiere lunar missions and interplanetary probes, but also included many satellites directed at earth applications, both military and civilian. Most of the military satellites came under the cover of the Cosmos series, and include both reconnaissance and surveillance satellites, and other functions.

The direct earth application satellites include science, communications, and weather. Many of the scientific satellites were under the cover of the Cosmos series again, but also Prognoz series. Also in the 1970s, the Soviet Union initiated the Intercosmos series of satellites that were intentionally built to accommodate foreign payloads and sensors, primarily from the Eastern Block or Warsaw Pact nations.

In the areas of communications, it is said that Russian technology always trailed the United States by five years or so. But it was in the area of communications satellites that Russia pioneered the use of a new orbit that was named after the satellite, the Molniya or high inclination/elliptical orbit. Much of Russian territory is in the high northern regions where geosynchronous satellites might not reach. So the Molniya satellites were manufactured primarily to cover all of the Soviet Union, including these high northern regions. This particular series has gone through three versions, Molniya-1, Molniya-2, and Molniya-3. The next step was 24-hour or geosynchronous satellites. These were divided into several types: standard TV and communications, called Gorizont and Raduga, and direct broadcast called Ekran, which were initially developed in the 1970s.

Weather satellites in the Soviet Union were slow to develop. The United States started in 1960 with the Tiros series, but it wasn't until 1969 that the first Russian weather satellite, Meteor-1, was launched, and was viewed by President Charles DeGaulle of France. A second series called Meteor-2 began operations in 1975.

European, Asian, and Commercial Space Programs

EUROPE

The first international satellite to be launched was the UK/USA joint Ariel 1 orbited in 1962 by an American Delta rocket from Cape Canaveral. The first non-USA / USSR satellite to be launched by an in-house built booster was the French Asterix sent into space in 1965 by a Diamant rocket. In the 1960s, Europe always wanted its own internal satellite and rocket design and manufacturing capability independent of the two superpowers. To accomplish this, two organizations were founded, the European Space Research Organization (ESRO) in 1962, and the European Launcher Development Organization (ELDO) in 1964. During the 60s, many European satellites continued to be launched but primarily by American boosters. However, for over ten years, ESRO and ELDO could not accomplish the task of determining a common European policy for space. In 1975, a new organization emerged that combined the previous two, the European Space Agency (ESA). It was under ESA leadership that Europe would emerge within five years as a dominant space launch power.

ASIA

Two other space powers also flexed their muscles in the 70s, Japan and the People's Republic of China (PRC). Japan would become only the fourth nation in February 1970 to independently build and launch its own satellite. Two months later, in April 1970, the PRC would orbit its first satellite, the heaviest first spacecraft ever orbited by any space power. Between these two countries, China and Japan, 23 satellites would be launched. Asia had entered the space stage.

COMMERCIAL

Communications satellites became a commercial success in the 1970s. During the 60s, the dominant commercial comm satellite models were the Intelsats II and III. In the 1970s, the Intelsat IV model would take over. But other competitors from the United States and Europe would emerge.

The 1980's

Introduction

The theme of the 1980s could be "Shuttle to Space Command to Star Wars to Space Station (Part 1)." The 80s decade began with final ground and air testing of the Space Transportation System (STS), leading to the first manned shuttle launch in April 1981. But the high hopes of the American reusable manned space system were dashed in January 1986 with the destruction during launch of the Space Shuttle CHALLENGER. It took over two years for the civilian space program to recover from this disaster. But recover it did, and the shuttle system remained the heart and soul of the NASA program during this decade. Because of the budget drain to fund development of the shuttle, only two interplanetary probes were designed, built and launched in the 1980s. They were Galileo destined for Jupiter, and Magellan bound for Venus. NASA continued with its responsibilities for advanced spacecraft technology, space science and earth application satellites.

In the 1980s, American military launch vehicles fared no better than their civilian counterpart when within a six-month period, the Air Force experienced two Titan 34D launch failures between 1985 and 1986. But the 1980s could be called the beginning of the maturity of Air Force space system. With the ever growing capability of military spacecraft, though acquired and handled by Space Systems Division at Los Angeles Air Force Base (an acquisition command base), many of these space systems were operational controlled by many organizations. By the early 80s, the military establishment felt that a formal operational space organization was needed and should come into being. In 1982, Air Force Space Command was created. It was also during the 1980s in the Reagan administration that the Space Defense Initiative or SDI, commonly called Star Wars, began. It was to provide an anti-ballistic missile shield for the whole country. Many of the military space missions such as early warning, communications, nuclear detection, global positioning and weather either began, matured or were enhanced in this time period.

It was in the late 1970s and continuing into the 1980s that the Soviet Union found a focus for its space leadership which it has not relinquished to this day. This is in the area of extended stay manned space stations. Starting with Salyut 6 in 1977, continuing with Salyut 7 in 1986, and finalized with the MIR space complex, Russian cosmonauts have been continuously in orbit since then. Two more segments of the MIR space station were launched in the 80s, the Kvant and the Kvant 2 modules. Because the Americans had a reusable space shuttle, the Soviet Union attempted to design and build their own. It was launched twice in the late 80s, both unmanned. They continued their exploration of Venus (with their Venera series) and Mars (with the new Phobos series) and attempted a rather complex dual mission spacecraft, Vega, which went past Venus and then flew by Haley's Comet.

Europe continued to develop its own internal spacecraft and launch vehicle design and manufacturing capability. With the emergence of ESA, development of the Ariane family of boosters began. Launch of the first Ariane 1 was in 1979, and by the mid-1980s, ESA had an excellent foothold in the communications satellites launch business. With the CHALLENGER explosion and the hiatus of American boosters for two years, ESA and Ariane took control of the launch business and have not relinquished it. The mainstay of the present boosters, the Ariane-4, began design in the mid-80s with first launch in 1988. In the area of satellite design, ESA took the lead in developing a European weather system working in conjunction with the American NOAA GEOS system. It also began design and manufacture of the French SPOT remote sensing satellite system, and took part in the Giotto interplanetary probe to Haley's Comet.

Asia continued its development of its own systems, which now included Japan, PRC and India. India began to flex its technological muscles and develop its own satellites and launch vehicles. Many Middle East countries also began purchasing commercial communications satellites from either the United States or Europe and operating them for the own regional use.

American Space Policy

Two presidents, Presidents Ronald Reagan and George Bush controlled American space policy in the 1980s. In 1982, President Reagan announced that there would be a new reinvigoration of the American space program. However, it would not be until 1984 that he would announce during the State of the Union Address that he supported the building of a new space station. He hoped that it would be finished by 1992, the 500th anniversary of Columbus coming to America. But the funding problems that continually plagued the Space Shuttle also followed the space station. NASA was prepared for this having learned from its STS lessons. The space station could not constitute a large percentage of its budget since the White House would not support that. Because of the lukewarm support from Congress and supposed indifference by the White House, the space station would not take root and begin its assembly process until 1998 under a Democratic President, Bill Clinton. President George Bush made an attempt to jump-start a manned mission to Mars. One can see the various stepping stones to the universe (reusable shuttle, space station, manned Mars missions) starting with Hermann Oberth's vision of the 1920s, and von Braun's articles in the 1950s, and NASA big push under President Nixon. But it would take time to convince a President and the Congress. In the case of President Bush's recommendations for Mars, they fell on deaf in the Congress. There just was not any political support for it at the time.

American Civilian Space Program (NASA)

INTRODUCTION

This was to be the era of the reusable Space Transportation System (STS), or Space Shuttle for short. Indeed, the space shuttle was to capture the American public attention for the whole decade for better or worse. But with the growing budgets demanding by the shuttle, NASA was able to build and launch two several interplanetary probes, but still missed an opportunity to fly-by Haley's Comet. Space science and planetary physics made strong showing during this decade.

MANNED

On April 12, 1981, 20 years to the day since the first man (Yuri Gagarin) went into orbit, the Space Shuttle COLUMBIA made its orbital debut, orbiting two days and testing out all systems. It was commanded by an astronaut veteran, John Young, who had flown on 4 other missions including a walk on the Moon during Apollo 16, accompanied by Robert Crippen, a rookie astronaut. The flight made it through with flying colors except for a possible scare when it was noticed that several heat shield tiles had come loose from the tail. But this proved to be no problem, and the COLUMBIA landed at Edwards Air Force Base in California within out incident to a crowd estimated at 20,000 people. COLUMBIA became the first reusable space shuttle on November 12, 1981, when it was launched into space for a second time. NASA and its shuttle was on its way. Five shuttle spacecraft were built, one test vehicle (ENTERPRISE) and four flight vehicles (COLUMBIA, CHALLENGER, DISCOVERY and ATLANTIS). But the shuttle had been first sold to Congress and the White House with the premise of low operational cost and easy access to space. The shuttle system was envisioned to fly 24 times a year. By early 1986, the whole STS fleet had only flown 24 times, and then January 28, 1986 came. The space shuttle CHALLENGER blew up 72 seconds after launch due to a failed O-ring in one of the solid rocket boosters. What made the tragedy worse was that the crew represented such a cross-section of the American community of sex, race and religious background. It had also included the Teacher-In-Space, and the whole country mourned their loss. The Rogers Commission was set up to investigate the accident and recommend changes. Over two years after the explosion of CHALLENGER, the space shuttle Discovery was launched to recertify the solid rocket boosters for manned flight and restart NASA manned spaceflight program. Another space shuttle was ordered, the ENDEAVOUR to replace the destroyed vehicle. NASA tried to expand the scientific return from the shuttle flights and included ESA as partners in the program. ESA's contribution to the shuttle system was the Spacelab module that could fit into the shuttle bay, and be used for scientific or business experimentation. The Long Duration Exposure Facility (LDEF) was another unmanned satellite let loose by the shuttle and returned several years later to determine the effects on materials of long exposure to the space environment. The decade ended with NASA still tied to the STS, and being forced to expand the expendable launch vehicle fleet which the STS was originally planned to replace. But the promise of late 1969 to 1971 with the vision of greater manned exploration was still pursued, and the second building block of a space station was now actively pushed. There were jump-starts to get Space Station Freedom going, but NASA received the reception it got with the shuttle when it came to getting money for the project. Whereas the STS only went through several years of indecision due to the financial merry-go-round between the White House and Congress, the space station project would be tossed around for over 10 years before a final design was accepted and metal being cut. NASA to its credit, got ESA, Russia and Japan to join in the program, making it an international project. However, in making it an international project, NASA would lose some overall control of it. NASA saw the space station as its program of the 90s as STS was its program for the 80s. Even at the end of the 1980s, President Bush proposed a Space Exploration Initiative (SEI) that would get America back to the Moon by the year 2000 and to Mars by 2010. But the price of \$500 billion over 20 years was just too great and Congress never gave it serious consideration.

INTERPLANETARY

The 80s could be called the decade of near misses. Only two major projects were initiated in the 1980s, and one was ignored. These projects were the Magellan spacecraft, which was to be sent to the Planet Venus, and the Galileo probe that was to be sent to the Planet Jupiter. Both were launched late in the decade with the majority of their data being collected in the 90s. The one missed opportunity was to send a spacecraft to fly-by Haley's Comet.

Venus was last explored by American spacecraft Pioneer-Venus 1 and 2 and had performed low-resolution radar traces of almost the whole planet. The Magellan probe was to perform a high-resolution radar mapping of Venus. The Russians had done this earlier but at a much lower resolution. Because of increasing scientific mission requirements and rising project costs, Magellan was slated to be canceled. But the project was reduced to totally focusing on the radar-mapping mission only. By borrowing an old communications dish from the Voyager program, and using it for both the radar mapping mission and communicating with Earth lowered the costs enough to keep the mission. Launched in 1989 from the space shuttle and using an Inertial Upper Stage (IUS) to send the spacecraft into outer space, Magellan arrived at Venus in 1990 and completed its mission by 1993. It showed Venus to be more volcanically active than previously thought with many deep canyons and valleys like Mars.

The last time an American probe investigated Jupiter was Voyagers 1 and 2 in the 1970s, which were just fly-by missions. The scientific community wanted a more thorough, focused examination of our solar system's largest planet. Galileo was designed and built by the Jet Propulsion Lab (JPL), and was originally planned to be launched from a space shuttle with a high-performance Centaur upper stage to send it on its way to Jupiter in the mid 1980s. But with the CHALLENGER disaster, use of the liquid oxygen / liquid hydrogen Centaur upper stage on the shuttle was ruled to be too dangerous. So Galileo was put back into storage, and JPL planners looked at the Titan rocket as a new launch vehicle. Because the Centaur vehicle was not quite developed yet, the only available upper stage was the two-stage solid-propellant Inertial Upper Stage, and it would also call for using planet gravity assists to get to Jupiter. This had been done before on the Pioneer 10 and 11 series, the Voyager 1 and 2 spacecraft, and the Mariner 10 probes. But the Galileo gravity-assists required multiple assists that had never been attempted before. Galileo was launched in 1989 aboard a space shuttle, and would not reach Jupiter until the mid-90s. It had troubles from the beginning. The major problem was the inability of the high-gain antenna to completely deploy. Therefore ground controllers had to resort to the low-gain antennas. But high hopes were held out for the program.

The major disappointment for the 1980s was the missed opportunity to send a major American probe to investigate Haley's Comet. Haley's Comet comes in the vicinity of Earth only once every 76 years, but scientists were unable to convince Congress of the importance of the project. Eventually ESA, the Soviet Union and Japan sent spacecraft to explore the comet.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

NASA continued to advance its mastery in the areas of advanced technology spacecraft design, along with earth and space science applications. Two more second-generation Landsat satellites were launched (Landsat 4 and 5). They built on the foundations by the previous 4 satellites with greater capabilities to make greater detailed land-use information. The data was used for crop forecasting, vegetation-land usage, and lake and river flood damage reporting. But competition from the French SPOT satellite system began.

Space science once again took the forefront. It included such satellites as the Solar Max Mission (SMM) which was designed to observe sun activities over a wide region of wavelengths and to cover the maximum period of the sunspot cycles. SMM also made history by being the first satellite to be repaired by a shuttle crew in 1984. The international Infrared Astronomical Satellite (IRAS) which was sponsored by the United States, Great Britain and The Netherlands had a prime mission of providing a complete infrared map of the observable universe. Earth Radiation Budget Satellite (ERBS) was designed to study solar radiation energy. The Cosmic Background Explorer (COBE) was designed with three instruments to measure diffuse infrared energy that abounds in the universe originating with the Big Bang. NASA saved the best to end the 1980s and this was the Hubble Space Telescope (HST). The orbiting telescope was to outperform all ground based telescopes because it did not have to contend with the earth's atmosphere. High hopes were placed on the HST, but when it was put on orbit, it was found that a lens aberration had reduced the capability of the system, causing NASA great embarrassment. This difficulty was corrected on a later shuttle repair mission, and HST has become one of the crowning technological accomplishments for NASA as it continues to pierce the secrets of the star-filled heavens. <>To help reduce the costs of communicating with satellites, NASA began to close down its world-wide network of tracking stations and replacing them with the Tracking and Data Relay Satellite System (TDRSS). With two operational satellites and one as an on-orbit backup spare, NASA is able to communicate 85% of the time with most of its satellites. Previously with its ground network, it was only able to keep in touch with its space assets 15-20 % of the time. The TDRSS system gave it greater coverage at a lesser cost.

American Military Space Program: Initial Military Operations

INTRODUCTION

The two great activities of the 1980s for military space was the formation of Air Force Space Command (AFSPC) in 1982 and the initiation of the Strategic Defense Initiative (SDI) under President Ronald Reagan in 1984. Also with the advent of AFSPC, Air Force war planners began taking a more serious and thorough look at the tactical uses of space based systems.

PHOTO RECONNAISSANCE

Intelligence missions continued into this decade but their missions remain classified to this present day.

ANTI-SATELLITE WEAPONS (ASAT)

One type of weapon geared to negating the use of space systems is the anti-satellite weapon. During the 1960s, the USAF developed a ground based system called Program 437 which consisted of a Thor Intermediate Range Ballistic Missile (IRBM) with a nuclear warhead. The idea was to launch the missile in the direction of an enemy satellite and detonate the nuclear warhead. The system worked quite well except that although it would destroy an adversary's space system, it might also destroy your own systems. The Air Force deployed Program 437 on Johnston Island in the Pacific, and it remained operational until 1970. In 1975, the Air Force began development of an advanced anti-satellite system. The new system would use a two-stage rocket with a miniature infrared homing sensor device and be launched from an F-15. It would then home in on the target using the infrared sensor and destroy the enemy satellite by impacting it. The first free-flight test took place in 1984, and it succeeded in destroying an American military technology satellite in 1985. However, the program was canceled in 1988 due to budget constraints and Congressional restrictions.

WEATHER (METEOROLOGY)

The military weather satellite system, DMSP, continued to evolve and improve. There were four launches of a new class of meteorological satellites, the 5D-2 model, during the 1980s using a new launch vehicle, the former Atlas E ICBM. These former ICBMs were refurbished to be medium weight launch vehicles.

COMMUNICATIONS

The Navy continued to be the pioneers in tactical use of space based systems with its FltSatCom system. Eight satellites for this system were launched in the 1980s giving excellent coverage for tactical users. Because of the explosion for the need of military communications, the Navy realized that its own internal system was incapable of supporting all of its needs. It also needed a follow-on system to the FltSatCom satellites. Congress directed that the DoD should also make more use of leased commercial facilities and the Leasat satellites were designed. Five Leasats were launched between 1984 and 1990, and prepared the way for its own successor system, the UHF Follow-On, also called UFO. For the Air Force, they finished launching the last of its DSCS II satellites in 1982, and began deployment of its advanced DSCS III system. A total of four DSCS III satellites were launched in the 1980s.

EARLY MISSILE WARNING

The Defense Support Program (DSP) continued to be the linchpin of our strategic early warning system for ballistic missiles launches. It had become so good and so reliable that it had completely replace some of the older radar sites built during the 1950s and 60s for early warning. Eight DSP satellites composed of three different upgrades were launched in the 1970s. In the 1980s, five satellites were orbited of the Multi-Orbit Satellites/Product Improvement Modification (MOS/PIM), Phase II Upgrade and DSP-1 class satellites. The Phase II Upgrade class increased the number of infrared detectors from 2000 to 6000 detectors, increasing its capability considerably. The first DSP-1 satellite (Flight 14) became the first payload for the new class of heavy weight booster, the Titan IV.

NAVIGATION (GLOBAL POSITIONING)

During the 1970s, four of the Block I satellites were launched, primarily to test the concept of space based global positioning, and testing out ground equipment. By the beginning of the 1980s, the Air Force began launching the full constellation of 24 planned satellites. Eleven more Block I GPS spacecraft were orbited, and then five newer Block II ones by 1989. But this was still short of the planned full number of 24. The whole constellation should have been in place by the end of the 80s, but budget cuts and emphasis on aircraft kept cutting into space funding. This was to have some consequences during the first use of the GPS system during war.

SPACE COMMAND

Between 1958 and 1982, military activities grew in both scope and importance. The military is always looking for what it calls "force multiplier," those activities that will enhance the capability of our soldiers, and space became one of those leading edge force multipliers that would eventually change the face of warfare. Essentially, space systems are combat support systems. However, because no separate operating structure existed within any of the military services, space activities remained primarily under the control of the Air Force's acquisition arm, Air Force Systems Command. After a long period of study, the corporate Air Force established Air Force Space Command (AFSPC) on September 1, 1982 at Peterson Air Force Base, in Colorado Springs, Colorado. It took immediate operational control of two space systems, the early warning satellite DSP, and the weather satellite, DMSP. In 1983, it took command of all ground based radar systems, and In 1984, it assumed operational control of the existing GPS network constellation. The fourth space mission, communications, remained the responsibility of the Defense Information Systems Agency (DISA). In 1987, AFSPC took full control of Sunnyvale Air Force Station, which at that point was the primary command and control center for Air Force space systems. In 1990, all satellite launch operations were transferred from Air Force Systems Command to Air Force Space Command. Finally, in 1993 it took operational possession of the Consolidated Space Operations Center (CSOC), at Falcon Air Force Base, Colorado which assumed primary command of most military space systems while Sunnyvale took on a backup role. This new command had grown up considerably and quite quickly in less than eight years.

STRATEGIC DEFENSE INITIATIVE (SDI)

In 1983, President Regan unveiled his Strategic Defense Initiative, a system of earth-based and space-based warning and weapon systems that would protect the United States from ballistic missile attack. Long range planner for SDIO also included such exotic weapon systems as lasers and directed-energy weapons. In 1987, three prime systems were selected for development. These were the Boost Surveillance and Tracking System (BSTS) which was to track enemy warheads early in their flights. Next was the Space Surveillance and Tracking System (SSTS) which was to track the warheads in the mid-course of their ballistic trajectories. Finally, there was the Space-Based Interceptor (SBI), which consisted of hundred of earth-orbiting satellites that would destroy enemy missiles by impact. These three systems were to form the initial phase of SDI deployment. At first all of these programs were managed by the Strategic Defense Initiative Office (SDIO), which later became the Ballistic Missile Defense Organization in the 1990s. Eventually BSTS and BSI were given over to Space Systems Division at Los Angeles Air Force Base to acquire and manage, while SSTS remained under SDIO control. By the end of the decade, the wisdom of SDI was being questioned by Congress and the overall effort was cut back.

Russian Space Program

INTRODUCTION

During this period, the Soviet Union established its dominance in the areas of space stations and continuous manning of those stations. With the continuous manning of Salyut 6 launched in the 1970s, and the orbiting of Salyut 7 in 1982, and finally the establishment of the first segment of a long term space complex with the MIR system, Russia made the second building block to the stars - a space station. America had established the first building block with a reusable space shuttle. Russia attempted to fill the void of a reusable shuttle with its own Buran and Energia launch vehicle, but the collapsing Soviet Union could not provide the funds to complete that project. Russia continued with its own interplanetary program including sending more spacecraft to Venus and Mars, and also conducting a rather complex mission to Venus and Haley's Comet. Finally upgrades to various communications and weather systems continued.

MANNED

Although Salyut 6 was launched in 1977, the space station continued to be used through 1982 when it was deliberately deorbited. During that five years of operations, it was occupied by five long term crews, eleven visiting crews, and had been supplied by the Progress Transport spacecraft twelve times. It was also hooked to the Cosmos 1267 TKS module, the first time that two large structures had been remotely joined together in space. This was an enviable record, but the best was yet to come. Russia wanted to establish a permanent presence in space, and this occurred with the Salyut 7 space station, and then establish a long term structure with the MIR complex. Salyut 7 was launched in early 1982 with the goal of permanent space presence and this was accomplished by changing crews. This crew replacement operation made continuous manned permanent orbiting space stations a reality. During Salyut 7's lifetime, it was occupied by six long term crews, and visited by four short-term crews. Also during this time period, it was hooked to Cosmos 1443 and 1686 TKS modules. The crowning jewel of Soviet space stations was the MIR complex. The base module was launched in 1986, and during the remaining part of the decade it was joined by two other modules, a Kvant and Kvant 2 segments. The complex was designed for up to three additional modules, and could be remotely supplied by Progress transport ships. Also during this decade, Russia upgraded its basic Soyuz spacecraft from a "T" model to a "TM" model. It also upgraded the Progress spacecraft from the basic model to an "M" model. To complete the overall manned program, Russia wanted to replace its Soyuz manned spacecraft which had been in operations since 1967 with a reusable craft similar to the American space shuttle. They came up with the Buran shuttle attached to the Energia booster. There are definite similarities between the American and Russian reusable spacecraft, but there are definite differences. Both have delta wing orbiters, but the American STS has its main engines attached to the manned vehicle, while the Russian Buran does not. Both have a central core tank containing liquid oxygen and liquid hydrogen, but where the main engines are attached to the base of the American orbiter, the Russian engines are attached to the base of the core launch vehicle. Finally the boosters of the American STS are solid rockets, while the Russian Buran boosters are liquid fueled. This Russian boosters are dual purpose and can be used also as launch vehicles in their own right. So the Russian Buran does have some definite advantages that the American STS does not, even though they do look very much alike. Unfortunately, the Energia / Buran combination attempted only two launches. The first launch in 1987 consisted of the Energia launch vehicle with a cargo compartment attached. The launch vehicle performed flawlessly but the cargo compartment separated badly. The second attempt in 1988 consisted of a Buran / Energia combination. The Buran was launched, circled the earth for one orbit, and returned and landed successfully by remote control. By this time, the Soviet Union economy was collapsing and could no longer support the development of Energia / Buran. The program was eventually canceled, and one of the Buran test vehicles can be seen in a Moscow park as a tourist attraction.

PLANETARY

The Soviet Union maintained a vigorous planetary program during this decade. They attempted four launches to Venus with the Venera series, two launches to Mars with the Phobos series, and sent two vehicles on a dual mission to Venus and Haley's Comet, the Vega series. The first two Venus launches, Venera 13 and 14 were lander vehicles. Russia always sent their planetary probes in pairs to improve the possibility of success. Both vehicles were launched in 1981, landed on Venus in 1982, and provided the first color pictures of the surface along with the first soil analysis. Venera 13 transmitted from the surface of Venus for 127 minutes while Venera 14 for 57 minutes. The second set of Venus launches, Venera 15 and 16, were radar mapping missions. Both were launched in 1983 and mapped the northern hemisphere of the planet at a 1-2 km resolution. Only in 1988 when the American Magellan spacecraft was launched to Venus did we get a mapping mission at a better resolution. The two Vega spacecraft served three distinct purposes - quite a sophisticated mission. First was to flyby Venus and send a lander to the surface. Second, while the bus vehicle was passing Venus, it would also release a French-built balloon experiment into Venus' atmosphere. Third, it would flyby Haley's Comet as a vanguard mission preparing the way for the more sophisticated ESA built Giotto planetary spacecraft. All three missions were carried out successfully by both Vega 1 and 2. Finally, the Soviet Union sent two advanced Phobos probes to Mars in 1988. Unfortunately, both missions experienced problems on the way, and failed to return much useful data on Mars.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

During this time period, Russian continued to improve on its communications, weather and other earth applications satellites. They replenished their communications satellites with the Molniya-3 type, Gorizont, Raduga and Ekran series. They upgraded their weather satellite system from the Meteor-2 series to Meteor-3 series in 1985. Finally, they continued their earth and space science applications with the Prognoz, Okean, Foton and Resurs series of satellites.

European, Asian, and Commercial Space Programs

EUROPE

During this decade, Europe broke away from its dependence on the United States for unmanned launchers, but still chose to cooperate with NASA on the STS system and future space station programs for most manned missions. After the CHALLENGER disaster, ESA with its Ariane family of booster vehicles took over the majority of the communication satellites launch business. ESA continued to design, develop and manufacture the boosters, but then gave it over to a new organization, Arianespace, to market its launch services. Europe showed its confidence in its capabilities by also launching its own designed and built interplanetary spacecraft when it sent the Giotti probe to flyby Haley's Comet in 1985. This was an event that NASA was unable to cover, and if it had not been for the Europeans, our understanding of comet activity would not have been as complete without the Giotti mission. France and Germany began to develop more sophisticated communications satellites, and France turned to earth remote-sensing as another application they could market. SPOT I was launched in 1985 in direct competition with the American Landsat series. At first, it did not have the resolution as Landsat, but as the SPOT system evolved, in many ways, it surpassed its American counterpart. Europe had definitely come of age in the 1980s, and a space power to reckon with.

ASIA

Japan and the PRC continued to advance their own respective space industries. Two more Asian nations joined the space club by building their own satellites and launching them with their own booster, India in 1981, and Israel in 1988. Japan showed the maturity of its industry by building and launching its first interplanetary spacecraft, Sakigake, in 1985 and sending it to flyby Haley's Comet along with the Russian Vega series and the ESA Giotti probe.

COMMERCIAL

Evolution of the communications market continued, with many African and other Asian countries wanting to operate their own regional communication systems. There was a strong effort by the United States and France to develop the earth remote sensing market, but this did not take off as well as expected.

The 1990's

Introduction

The theme of the 1990s was and is the use of military space based assets in "the First Space War" and Space Station (Part 2). The Kuwaiti War of 1990-1991 showed the force multiplier capability of military satellite systems to the world, and how space based combat support assets could help win a war in the area of early warning, global positioning and communications. Also during this time period, the International Space Station finally took root and began to be built. NASA's main manned program remained the shuttle, and with the collapse of the Soviet Union, their space program began to collapse as well for lack of funds. But the United States returned to Mars again with the Mars Rover and Surveyor, sent Cassini spacecraft to Saturn, and the Hubble Space Telescope continued to show the wonders of the heavens.

American Space Policy

A new administration took over in 1993, President William Jefferson Clinton, and showed their enthusiasm for the space program by quickly eliminating the National Space Council, an space advisory group to the President, which had been in existence since the Kennedy Administration. No new space initiatives were undertaken by the new President, but kept existing programs going, like the space station, planned planetary probes to Mars, and other space science and earth applications satellites.

American Civilian Space Program (NASA)

MANNED

The heart of the NASA programs has remained its shuttle fleet of four manned orbiters (COLUMBIA, DISCOVERY, ATLANTIS, ENDEAVOUR). By the end of the decade, the fleet will be almost 20 years old, and have flown over 150 missions. Although the shuttle was never able to meet its planned expectations of low cost and ready access to space, it was and is a marvelous manned technological machine that proved that a vehicle could be reusable and is laying the ground work for follow on manned spacecraft. The building blocks to space have always been a reusable shuttle, a space station, and manned expeditions to the Moon, Mars and beyond. NASA was finally able to initiate, design, build and start assembly of its International Space Station. Part of the agreement with Congress over beginning the Station program was to bring in the international community to help defray costs, and this NASA was able to do. There are almost a dozen international partners on the program including Japan, ESA and Russia. In fact, Russia is supplying two of the first three major components of the station based on MIR designs and technology and the country's experience in operating Salyut and MIR for over 20 years. Russia will also supply Soyuz spacecraft to act as emergency escape vehicles for the station early on in the program. Assembly began in 1998 with the launch of the first component from Russia, and then in 1999 with the first American component. Anticipating the international space station, the United States began sending American astronauts to the MIR space station complex.

INTERPLANETARY

Interplanetary exploration had a mild resurgence in the 1990s. Two probes launched in 1989, Magellan to Venus and Galileo to Jupiter, reached their destinations in the 90s. Magellan arrived at Venus 1990 and began radar mapping operations soon thereafter. Magellan showed that Venus was more geologically active than previous thought. Galileo arrived at Jupiter in 1995, and began exploration of the Jovian system. This included release of a probe into Jupiter's atmosphere and with precise orbital maneuvers, exploration of the many moons of this large planet. In 1992, NASA launched its first probe to Mars in over 15 years, the Mars Observer. Unfortunately, two days before reaching Mars, the Observer went dead when controllers at the Jet Propulsion Lab (JPL) attempted some pressurization tests for the propulsion and attitude control systems. NASA also sent the last great interplanetary probe Cassini to Saturn in 1997. It will reach Saturn in the next century. Two new probes were designed and launched in 1996 on Delta expendable boosters, the Mars Pathfinder and the Mars Global Surveyor. The country watched with delight when the Mars Pathfinder successfully landed on the Red Planet, and released its Mars Rover to roam over the Martian terrain. Finally in 1997, NASA returned to the Moon with its Lunar Prospector.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

NASA maintained a healthy space science and earth applications programs during this time period. These satellites include: the Combined Release and Radiation Effects Satellite (CRES) launched to perform a one-to-three year study of the earth's magnetic field; The Gamma Ray Observatory (GRO), the second in a series of four NASA Great Observatories, is a platform hosting four experiments that detect the gamma ray emissions of cataclysmic cosmic events (black holes, pulsars, quasars) during a 15-month sky survey mission; the Upper Atmosphere Research Satellite (UARS) was the first in a series of NASA environmental monitoring satellites; Extreme Ultraviolet Explorer (EUVE) was designed to study the heavens through the extreme ultraviolet (EUV) region of the electromagnetic spectrum; and Geotail was a scientific mission to explore the earth's geomagnetic tail and was cosponsored by NASA and the Japanese Institute of Space and Astronautical Science (ISAS). NASA also continued its advances in spacecraft technology with the Advanced Communications Technology Satellites (ACTS) which was a joint NASA, Defense Department and private industry venture.

American Military Space Program: Initial Military Operations

INTRODUCTION

This period will be best remembered as the time when military space systems were put to the test in actual warfare. Most of the systems performed quite well, and some beyond expectations. Truly the Kuwaiti War can be considered the first Space War. Many systems were enhanced or being ready to be replaced. Also, some classified programs officially were declassified.

PHOTO RECONNAISSANCE

In 1992, the existence of the National Reconnaissance Office (NRO) was officially announced. The NRO had been in existence since 1961 and the government determined that it was time to properly acknowledge this fact. Also in 1995, President Clinton declassified the CORONA program which was our nation's first photo reconnaissance satellite system.

WEATHER (METEOROLOGY)

The DMSP 5D-2 model continued to fly during the 1990s but will be replaced by the 5D-3 model at the end of the decade. Also the government decided that the civilian and military weather satellite systems should be combined into one national resource. This is progressing on schedule.

COMMUNICATIONS

The Navy began launching and operating the replacement for its FltSatCom satellite constellation, the Ultra-High Frequency Follow-On (UFO) satellites. A total of seven UFOs have been put into orbit to date. The Air Force was finally able to declare its DSCS III constellation fully operational with the launch of the fifth satellite in the series in 1993. As part of President Reagan's program to upgrade the country's strategic forces, the Air Force designed a satellite that would not suffer prolonged blackouts from high-altitude nuclear detonations using Extremely High Frequencies (EHF). This system was the Milstar communications satellite. Development of this system took over ten years, and the first launch was in 1994. The biggest supporters of the Milstar system are the tactical commanders in the field, our country's CINCs.

EARLY MISSILE WARNING

The Air Force continued to launch the DSP-1 model of this early warning satellite, and it has performed beyond expectations. But due to changing technologies and changing threats, the mission for DSP was greatly expanded. The original mission for DSP in 1970 when the program was first started was the detection of strategic missile launches and nuclear explosions. By 1990, that mission now included the detection of tactical missile launches. The Air Force decided to acquire a totally new system with more capability. During the 1990s, the new proposed systems started out as the Follow-On Early Warning System (FEWS), but became the Space Based Infrared System -High (SBIR-Hi). This new satellite is planned for first launch in 2004.

NAVIGATION (GLOBAL POSITIONING)

By the beginning of the Persian Gulf War, the planned GPS constellation was not totally operational. GPS attained initial operational capability in 1993, and full operational capability in 1994. From 1991 to 1994, there were 14 launches of the GPS II-A models navigation satellites because they had proven their worth in combat. During the latter part of the decade, the GPS II-R and II-F models were planned for and acquired. The first II-R model was launched in 1997.

PERSIAN GULF WAR

The war in Kuwait is called the first Space War. All space based assets were utilized tactically by all ground, naval and air troops. DMSP help in weather forecasting to determine ground sorties for planes, DSP detected the Scud missile launches and provided that information to Army Patriot batteries, and DSCS III communications satellites provided for 84% of the long-haul communications needs. But by far the satellite that proved itself in combat was the GPS satellites. They were used to guide Air Force and Navy aircraft to their targets, Army special forces helicopters depended on GPS to get them where they needed to go, and GPS receivers guided the movement of troops over hundreds of miles of featureless desert during the 100 hour war. From now on, no American military force could fight without the use of military space based assets.

Russian Space Program

MANNED

With the demise of the Soviet Union, the Russian space program was now controlled by three Republics of the Commonwealth of Independent States (CIS), Russia, the Ukraine, and Kazakstan. Russia had all the training facilities and command and control centers, the Ukraine built many of the booster rockets, and Kazakstan contained the most important launch center, Baikanour. Russia had maintained the MIR space station complex attached to the Kvant and Kvant 2 modules through the 1980s. During the 1990s, even with limited funds, the total planned MIR complex was completed by launching the remaining modules, Kristall, Spektr, and Priroda. The Kristall expansion module is dedicated to materials processing, the Spektr modules is to be used for remote sensing, and the final module, Priroda, would be used for microgravity experiments and remote sensing for international users. MIR was suppose to last for 15 years, but due to budget limitations and Russia's financial obligations to the International Space Station, MIR may be deorbited before the end of the decade.

PLANETARY

Russia attempted one interplanetary spacecraft during the 1990s, Mars 8. Unfortunately, it ended up in the Pacific Ocean after an upper stage malfunction.

SCIENCE, TECHNOLOGY, AND EARTH APPLICATIONS SATELLITES

Russia continued its programs for remote sensing with the Foton and Resurs satellites. It also launched a large scale commercial remote sensing spacecraft called Almaz 1 using radar imaging instead of photographic or infrared imaging similar to Landsat or SPOT. It had been constructed from the abandoned parts of a planned military space station. All of its communications and weather satellite program continue to be replenished. It has branched out into the unmanned materials processing arena with the Foton series. It has tried to mirror some of NASA Great Observatories series of satellites with its own spacecraft called Gamma used for observing gamma rays. Finally Russia joined the international weather monitoring group by supplying a geosynchronous Elektro 1 satellite.

European, Asian, and Commercial Space Programs

EUROPE

Europe continued to master all aspects of advanced technology, space science and earth applications, and interplanetary satellite programs. Germany had launched a Roentgen Satellite (Rosat) carrying a large telescope/ camera system to survey the X-ray sky. ESA built and launched from a shuttle the interplanetary probe Ulysses, a science mission to examine our Sun from an orbit that will take it over the north and south poles of the Sun. France orbited it several SPOT (SPOT 2 and 3) earth observation satellites to be used for commercial mapping and forestry, and agriculture and geological studies. Europe contributed to the world weather forecasting community by launching Meteosat 5 and 6 satellites, similar to NOAA's GOES system. Many second generation communications satellites were launched to support European commercial and military needs.

ASIA

Japan, the PRC and India continue to expand their space capabilities in the areas of launch vehicles, satellite manufacturing, and satellite applications such as weather, communications, earth resources, and interplanetary probes. Two new nations began using communication satellites for regional use, Thailand and Pakistan. Israel continued to develop its own space infrastructure for launch vehicles and satellite manufacturing. Satellites that Japan launched included Muses A on a lunar swingby mission with a lunar orbiter satellite attached (Hagoromo), Marine Observation Satellite IB (MOS 1B) to observe oceanic phenomena and earth terrain, Solar A which is a solar observation satellite carrying both soft and hard X-ray telescopes, Japanese Environmental Resources Satellite (JERS 1) which carries a synthetic aperture radar (SAR) and optical sensors, Astro-D which is an astronomy satellite carrying instruments to collect X-ray imagery, and finally the Geostationary Meteorological Satellite 5 (GMS-5) which joins weather satellites from NASA, ESA and Russia to form the worldwide weather forecasting network. The PRC capabilities continue to grow in the areas of communication satellites, earth resources, capsule recovery and launch services.

COMMERCIAL

Beside continuing into the commercial communications satellite market for other nations, business companies expanded into the commercial launch business. Such companies as Arianespace, PRC, Russia and the United States offer boosters for a price depending on the size of satellite that needs to be orbited. Even an international consortium is developing a launch platform to be used at sea. A new field of expansion is the global positioning market which grew considerably after the Persian Gulf War. And finally, remote sensing is finally beginning to expand but its prime customers seem to be the intelligence services of various countries.